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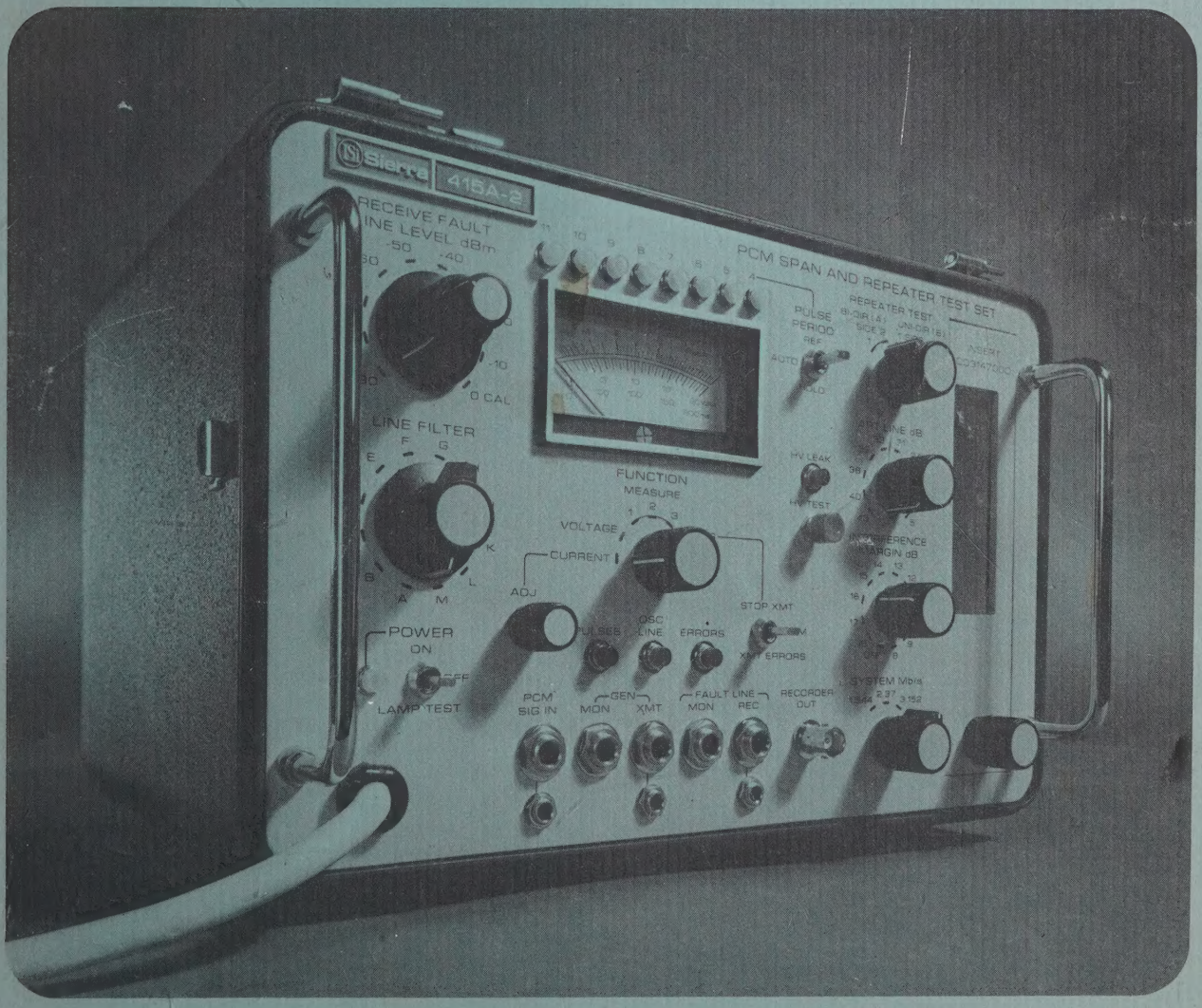
INSTRUMENT REPAIR SERVICE, INC.
3135 REPS MILLER RD.
NORCROSS, GA 30071

415A-2

PCM SPAN AND REPEATER TEST SET

OPERATION MANUAL



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Sierra
A DIVISION OF LEAR SIEGLER, INC.

INSTRUMENT REPAIR SERVICE, INC.
3135 REPS MILLER RD.
NORCROSS, GA 30071

WARNING

Before using this instrument:

1. Make sure that the line power cord plug is connected to a three-conductor line power outlet that has a protective (earth) ground. The protective action must not be negated by the use of an extension cord or adapter without a protective ground conductor, or by removal of the power cord plug ground terminal.

2. Make sure that all devices to be connected to this instrument are connected to protective (earth) ground.

LSI/SIERRA 415A-2
PCM SPAN AND REPEATER TEST SET
DESCRIPTION AND OPERATION

Figure 1-1. 415A-2 PCM Span and Repeater Test Set

CONTENTS PAGE

1. GENERAL 2
Central Office Testing 2
The Fault Line 2
Fault Line Testing 3
Fault Line Test Signals 4
Obscure Trouble Testing 6
Fault Line Test Method 7
Span Monitoring 8
End-to-End and Intermediate Testing 8
Span Line Monitoring 9
Pre-Installation Repeater Testing 9
Other Features 11

2. PHYSICAL DESCRIPTION 12
Controls and Indicators 12

3. FUNCTIONAL DESCRIPTION 15
Pattern Generator 15
Receiver 15
Error Detector 17
Repeater Tester 17
Power Supply 17

4. SPECIFICATIONS 18

5. OPERATION 19
Receiving Information 19
Power Requirements 19
Operational Test 20
Initial Set-Up 20
Fault Line Input Check 20
PCM Signal Input Check 21
Line Filter Transmission Check 21
System Mb/s Check 21
Span Line Fault Locating 22
Pre-Test Set-Up 22
Testing the Nearest Repeater 22
Testing Other Repeaters 23
Span Line Performance Tests 23
(A) At the Transmitting Terminal . 23
(B) At the Receiving Terminal 24
Attached Repeater Tests 24
(A) Pre-Test Set-Up 25
(B) Voltage Test 26
(C) Pulses and Errors Test 26
(D) Balance Test 26
(E) Signal-to-Noise Test 27
(F) Merit Test 27
(G) Testing Other Side of the Repeater 27
(H) Testing Additional Repeaters . 28

6. FIELD MAINTENANCE 28
General 28
Fuse Replacement 28
Lamp Replacement 28

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1. GENERAL

1.01 The 415A-2 PCM Span and Repeater Test Set is a multipurpose instrument for use in maintenance of PCM carrier line facilities and repeaters. Capabilities include span line fault locating, performance testing, in-service error monitoring, and repeater pre-installation tests.

1.02 The 415A-2 is designed to accommodate three separate line signals: 1.544 Mb/s (T1 type); 2.37 Mb/s (T148 type); and 3.152 Mb/s (T1C type).

CENTRAL OFFICE TESTING

1.03 The principal location for initial trouble testing of a PCM line is the Central Office. It is here that alarms are received and first measurements are made. Here troubles are analyzed and located or sectionalized. When technicians are dispatched to remote sites to make further tests, they generally call upon the Central Office for test signals or other support.

1.04 The PCM line (or Span) between Central Offices (Fig. 1-2) consists of cable pair sections and repeater locations. Cable type and repeater spacing are determined by the bit rate and other characteristics of a given PCM system. Since the line and its associated repeaters are distant from the Central Office, special methods are used for initial testing.

THE FAULT LINE

1.05 A unique feature of PCM transmission is the economical method by which remote repeaters and cable sections can be tested at the Central Office. The Fault Line (Fig. 1-3) is a special voice frequency cable pair which runs along the route of the PCM system between central offices. At each repeater location a single, special filter monitors the outputs of all repeaters in the housing. If a precisely defined test pattern is sent over the line, the filter will recognize and trap the audio component created by the pulse configuration. Output of the filter is connected to the Fault Line. Fault filters may be either passive (requiring no power) or active, and amplified, requiring power from the Central Office (applied via the Fault Line).

1.06 Fig. 1-3 shows the 415A-2 set up at Office A. Special Test Patterns are transmitted toward Office B at PCM line bit rates. Performance of repeaters and cable sections *toward Office B* is determined by tone information returned to Office A over the Fault Line. Unless special repeater/line switching arrangements are provided, Office B will test repeaters and cable sections *toward Office A*. Information will be returned to Office B over the Fault Line.

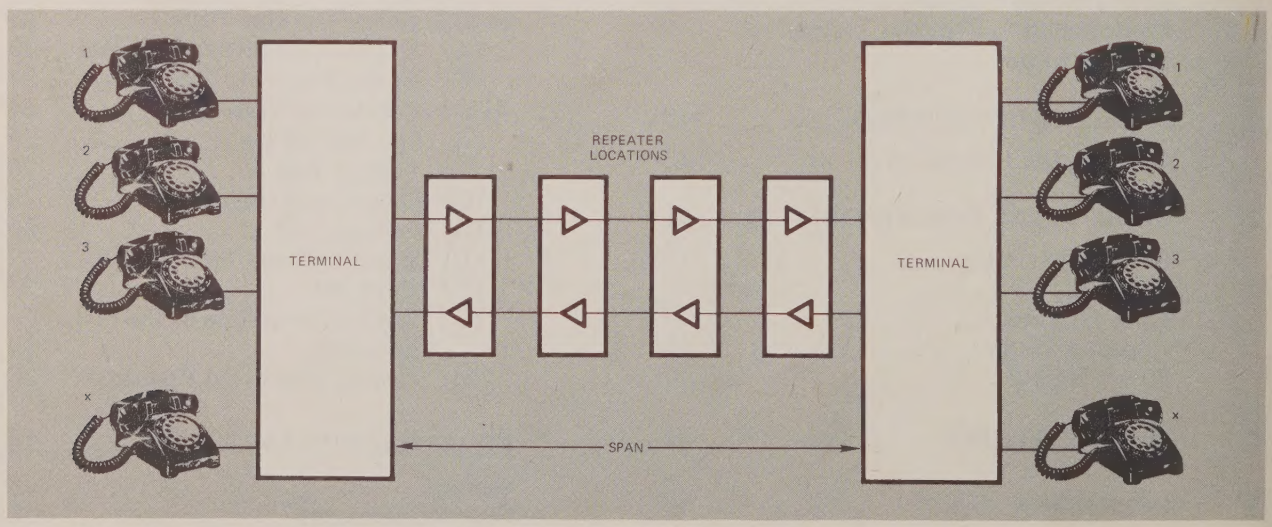

Figure 1-2. Typical PCM System Layout

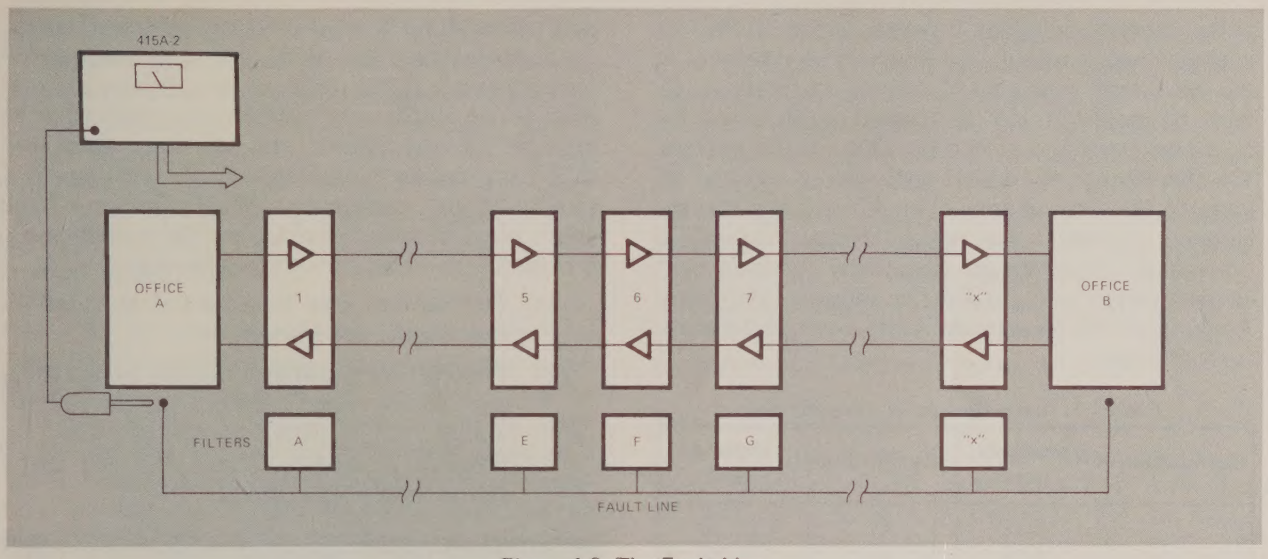

Figure 1-3. The Fault Line

FAULT LINE TESTING

1.07 Each Fault Line filter is tuned to a different audio frequency. It ignores normal PCM signals, which contain no audio component. In Fig. 1-4 the 415A-2 is set to generate a unique test signal consisting of pulse patterns which vary at an audio rate. The signal bit rate is the same as that of the PCM system under test. Thus, it travels along the line and is regenerated at each repeater location.

1.08 Filters are designated alphabetically, according to their audio frequency response characteristic (see Table 1-1). Fig. 1-4 shows filter A at repeater location1; filter B at location 2, filter C at location 3, etc. (Alphabetical sequence is convenient but not required for operation. Fig. 1-4 follows alphabetical sequence.) If a performance check at location 2 is desired, the 415A LINE FILTER switch is set to B. A special type of test pattern (MEASURE 1, 2 or 3) is then transmitted containing pulse groupings which superimpose an audio rate equal to the "B" frequency.

1.09 Filter A (at location 1) ignores the signal. However, filter B (at location 2) recognizes the audio component. Its band pass filtering characteristic derives a sine wave tone output whose *level* is dictated by the pulse density and accuracy of the pulses being regenerated and transmitted toward the next location. Tone is returned along the Fault Line and measured at the test set. If no

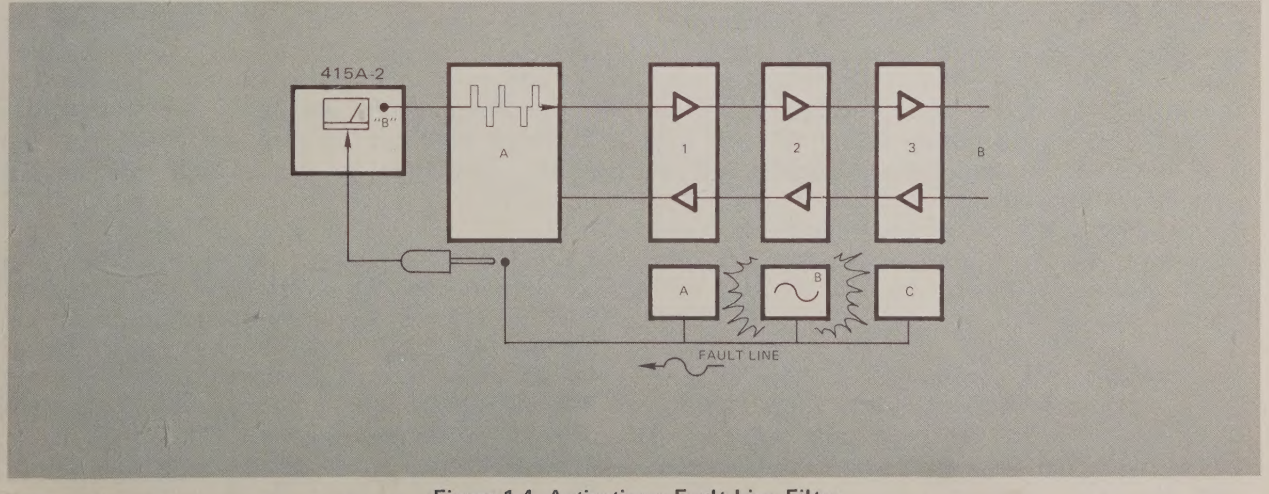

Figure 1-4. Activating a Fault Line Filter

pulse energy arrives at location 2 (or if the repeater is not working), no tone will be returned. If the repeater's regenerated output is faulty, tone may be weak. If the test signal is distorted by excessive errors on the line, the audio pattern will be disrupted, which will either weaken or increase the derived tone. The 415A-2 can also selectively increase the pulse density, causing a "marginal" repeater to eventually produce excessive errors and weaken or increase the tone. Analysis of the tone levels is the heart of accurate fault location.

Table 1-1. Audio Component Frequencies

Designation	Frequency (Hz)	Designation	Frequency (Hz)
A	832	G	1722
B	928	H	2008
C	1048	J	2193
D	1206	K	2413
E	1340	L	2680
F	1508	M	3017

FAULT LINE TEST SIGNALS

1.10 In order to understand the special nature of the Fault Line test signals, first consider the characteristics of a normal PCM pulse train. Binary digital pulses contain a significant DC component which makes transmission over long cable pairs (and through transformers) very difficult. The PCM signal is therefore converted to a bipolar pattern (Fig. 1-5) to remove the DC component. These pulses of positive polarity are transmitted "close together" (before the line or transformer has time to react to an individual pulse) and the resultant signal is *balanced*. It contains essentially no DC because the center point between the pulses is at zero potential (similar to the "zero crossing" point in an AC sine wave). Each repeater along the line will have maximum opportunity to recognize and regenerate the signal because each pulse is uniform in size and differs only in polarity. This bipolar pulse train can travel only a few thousand feet before its squared shape is rounded enough to require regeneration.

1.11 If a signal contains more pulses of one polarity than those of the opposite polarity, the center point will move from zero toward the voltage of the dominating pulses. A DC component now exists which adds distortion to the signal as it passes along the line and through transformers. This unbalanced pulse train is not easily regenerated by a repeater. If the pulse pattern changes *periodically* (at an audio rate) so that each polarity has its moment of domination, the DC component will shift back and forth correspondingly creating a low frequency AC component. While neither of the above conditions is desirable for PCM transmission, it *is* useful for Fault Line testing because:

(1) The pattern can be adjusted to cause an exact *audio* component.

(2) The varying unbalance caused by the shifting center point stresses the repeater's ability to perform, which can help to identify a marginal condition not easily found with normal signals.

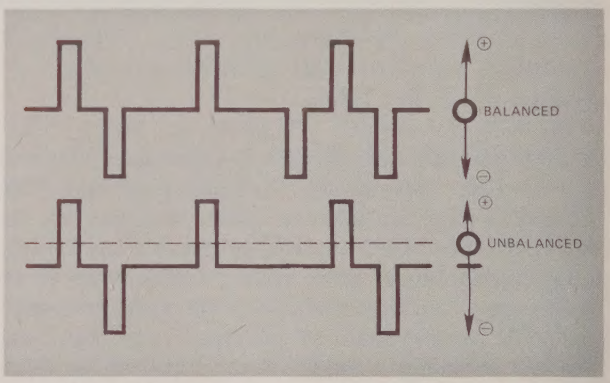

Figure 1-5. Balanced and Unbalanced Line Signal

1.12 Fig 1-6 illustrates three Fault Line test signals: MEASURE 1, MEASURE 2 and MEASURE 3. They are individually selected by the FUNCTION switch. Each signal is a predetermined pattern of pulses which deliberately introduce an audio component. Notice that the patterns are divided into the time span of two audio half-cycles. Actual time of the audio variation (i.e., its frequency) is determined by the setting of the LINE FILTER switch. Only a few of the pulses can be shown in the illustration, as suggested by the *straight* dashed lines.

1.13 The Fault Line test signal used most often is MEASURE 1. It consists of a series of *pulse trios*. Each trio is accompanied by a certain number of "empty" time slots (which determines the *density* of the signal; discussed later). During the time of the first audio half-cycle the pattern contains excess *positive* pulses. The voltage center point is displaced in a positive direction. During the second audio half-cycle the pattern contains

excess negative pulses. The center point is now displaced in a negative direction. The resulting component is low frequency energy varying at the desired audio rate. This energy is detected at one of the repeater locations, converted by the low pass filter into an audio tone, and returned on the Fault Line. In Fig. 1-6 the audio tone derived at the repeater (filter) location is shown by the superimposed dashed curves.

1.14 In addition to determining frequency of the outgoing audio component, the LINE FILTER switch conditions the *receiver* to recognize tone only within a narrow band around the same frequency. The 415A-2 can therefore operate on a relatively noisy Fault Line. *Actual* tone level is measured on the meter *if* the Vernier segment of the RECEIVE FAULT LINE LEVEL control is set to its CAL detent (full clockwise) position. (The "step" segment is adjusted until an up-scale meter reading is obtained. Actual tone level is a combination of the meter reading and the step setting.) The vernier control permits adjusting the level for a convenient "zero" reference point. If the selected repeater location is receiving and accurately regenerating a good test signal, the Fault Line tone should arrive at a good working level.

1.15 The typical PCM repeater contains separate output circuitry for each pulse polarity; one circuit generates positive pulses and the other generates negative pulses. Notice that MEASURE 1 test pulses are excess positive during the first audio half-cycle. At this time the repeater's positive output circuit is exercised. During the last audio half-cycle, polarity reverses to exercise the negative output circuit. If either output is open or distorted, total tone level is decreased. MEASURE 2 and 3 test patterns help determine if the trouble is caused by one polarity of pulses, or both.

1.16 MEASURE 2 checks the positive circuit. Its first audio half-cycle contains the same excess positive polarity as MEASURE 1. An audio component is formed as suggested by the rising curved line. During the last half-cycle the signal *does not* reverse; it becomes a series of bipolar pulse pairs which contain no audio information. Note that the dashed line flattens during this interval. MEASURE 2 frequency is the same as MEASURE 1; however, it is a function of positive pulses only. Audio energy trapped by the selected Fault Line filter will be weaker because only the positive pulse regenerator contains the component. Tone from a good circuit can be expected to drop

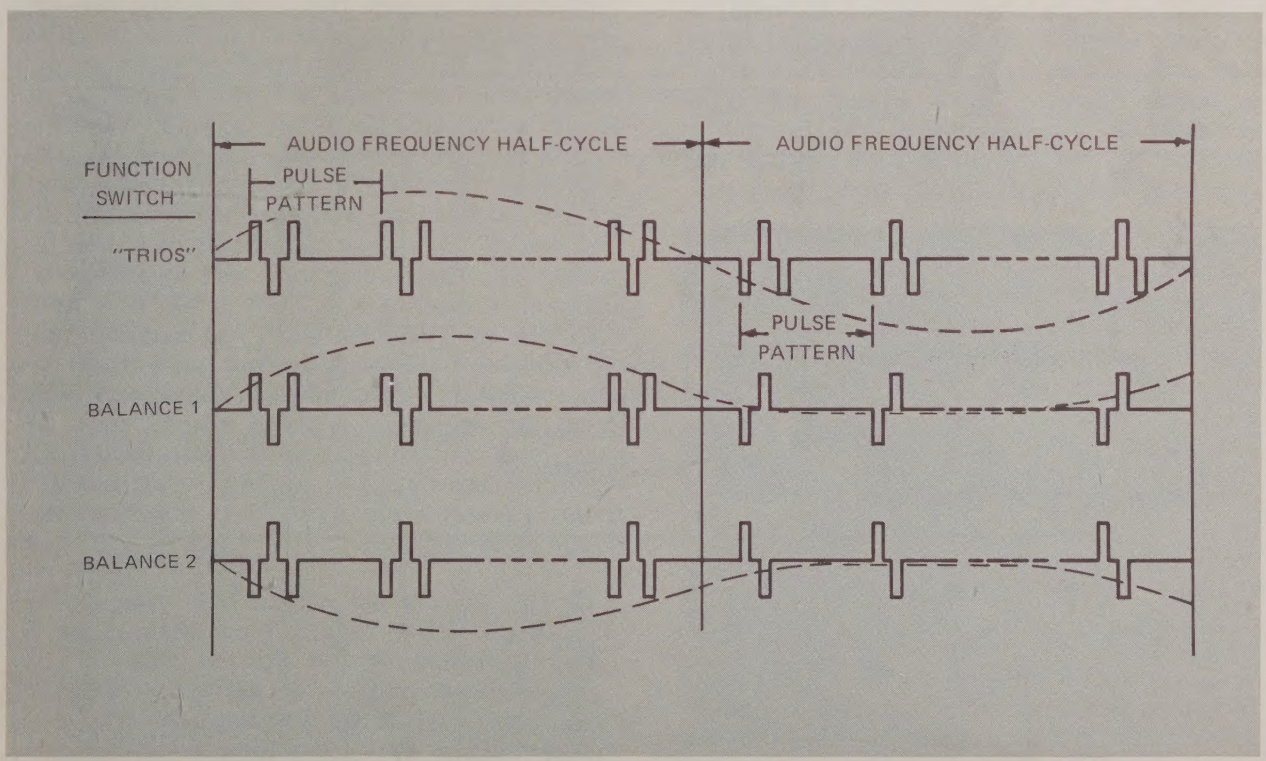

Figure 1-6. Basic Pulse Patterns for Fault Line Testing

about 6 dB below MEASURE 1 level.

1.17 MEASURE 3 test pattern is simply a reversal of excess polarity during the first audio half-cycle. Negative pulses predominate. The last half-cycle contains only pulse pairs. The resultant audio component is a function of negative pulses, therefore it indicates the repeater's negative polarity performance. Like MEASURE 2, the Fault Line tone will be about 6 dB below MEASURE 1.

1.18 If MEASURE 1 is weak, switch to MEASURE 2 and then to MEASURE 3. The levels of "2" and "3" should typically be within 1 dB of each other. If not, the repeater output circuit may be in trouble.

OBSCURE TROUBLE TESTING

1.19 It is possible that a marginal repeater or cable section could tolerate these special test signals, particularly if the pulse density is light. As shown in Fig. 1-7 (top illustration) the signal contains only three pulses in eleven time slots. Audio energy is relatively small, therefore the signal is not severely unbalanced. It is important to stress the line up to or beyond the point of maximum tolerance. This is accomplished by increasing the *density* of the MEASURE test pattern, which increases audio energy and aggravates the unbalanced condition. The function is controlled by the PULSE PERIOD switch and indicated by eight lamps directly above the meter.

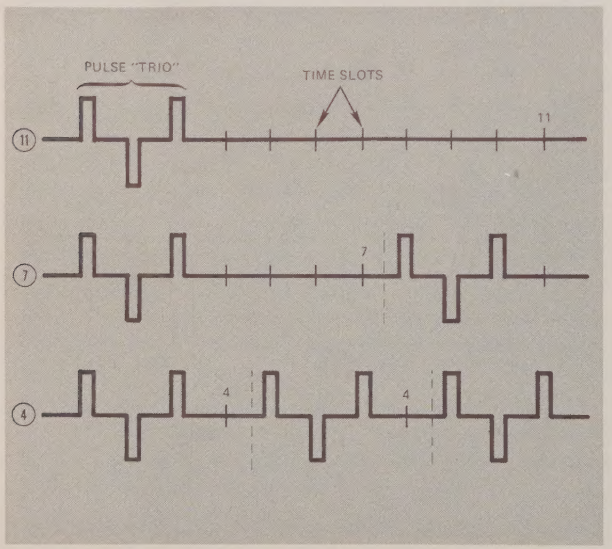

Figure 1-7. Examples of Pulse Periods (Signal Density)

1.20 The top illustration in Fig. 1-7 (one pulse trio in 11 time slots) corresponds to the REFERENCE position of the PULSE PERIOD switch (lamp "11" lighted). This is the condition at which the Fault Line tone is set at a reference point on the Meter. When the switch is positioned to AUTO, density begins to increase: 10, 9, 8, 7, etc., at intervals of about 2 seconds each. When "4" is reached the cycle stops until the PULSE PERIOD switch is moved to "REF" and back to "AUTO".

1.21 The center illustration in Fig. 1-7 shows the test pattern when lamp "7" is lighted. One pulse trio appears within each 7 time slots. Increased audio energy causes the bipolar signal "center point" to shift further from zero. All repeaters along the line must work harder to regenerate the signal accurately.

1.22 The bottom illustration (one pulse trio every 4 time slots) places added density and a high level of unbalance on the signal. Repeaters are heavily stressed in this condition.

1.23 The 415A-2 Fault Line receive circuit partially compensates for the increased energy by adding a small amount of attenuation to the incoming tone at *each step* of increasing density. This prevents masking of level variations produced by errors at the repeater. Readings should be recorded on a sheet similar to Tables 1-2 and 1-3. As density is increased (from "11" toward "4" on the PULSE PERIOD switch) you will observe various conditions, depending on the nature of the system: (1) The reading may tend to remain constant. (2) The reading may tend to increase in a smooth manner. (3) The reading may tend to decrease in a smooth manner. LOOK FOR A SIGNIFICANT CHANGE IN THE PATTERN. If a constant reading suddenly increases or decreases; if a steady increase suddenly pauses or begins to decrease; if a steady decrease takes a sudden plunge, stops, or rises . . . all may indicate a point at which excessive errors are occurring. Any significant change in the trend indicates a suspected faulty condition and should be checked out.

NOTE: The trend pattern may vary, or "wobble" slightly during progression of the test (increasing density). For this reason it is important to complete the test before drawing conclusions. If the trend begins to change, note whether or not it returns to the trend line.

1.24 Filters are generally listed in alphabetical order (A through M) along the line. However, alphabetical listing is not required, since any filter will work at any location.

NOTE: The 415A-2 can measure the *actual level* of the incoming Fault Line tone. It is suggested that the level from each repeater location be measured and recorded (MEAS 1, REF 11 position). During future tests, a change in the incoming level might indicate trouble at the repeater, at the filter, or on the Fault Line.

FAULT LINE TEST METHOD

1.25 Tables 1-2 and 1-3 are examples of how a record of readings is made during Density tests. There are several ways a record can be set up. In our examples, 0 dB is chosen as Reference Level. In order to obtain 0 dB on the meter, first select the desired repeater location (LINE FILTER switch); then set the FUNCTION control to MEASURE 1 and the PULSE PERIOD switch to REF. Density 11 is now transmitted to the span line, and tone should be returning on the Fault Line. Adjust the RECEIVE FAULT LINE LEVEL control (step and vernier segments) until the meter reads 0 dB.

NOTE: This procedure is repeated each time a different repeater location is selected.

In order to simplify and clarify the readings in Tables 1-2 and 1-3, *all levels measured ± 0.5 dB or less from the REF level are shown as "zero".* Levels beyond the ± 0.5 dB limit are duly recorded.

1.26 Table 1-2 is an example of readings which might be obtained on a good span line. The combination of repeater characteristics and the test set reponse characteristics produces a "rising" set of readings as density is increased. (Keep in mind that Tables 1-2 and 1-3 are specific examples based on specific considerations. Many variations could also be diagrammed.) It is important to note that errors on a PCM line are *cumulative*. Small amounts or distortion combine to become noticeable at more distant repeater locations. For this reason the meter readings of distant repeaters begin to deviate at lighter signal densities. As pulse density increases, carefully observe the meter and begin recording when ± 0.5 dB from Reference is encountered. The repeater location with Fault Line Filter

Table 1-2. Example Record of a Good Span of ALBO Repeaters

Line Filter	Pulse Period Switch Position								Faulty Section
	11	10	9	8	7	6	5	4	
A	REF	0	0	0	0	+0.6	+0.7	+0.8	
B	(0 dB)	0	0	0	0	+0.6	+0.8	+1.0	
C	↓	0	0	0	+0.6	+0.7	+0.9	+1.1	
D		0	0	0	+0.7	+0.9	+1.1	+1.3	
E		0	0	0	+0.8	+1.0	+1.3	+1.4	
F		0	0	+0.7	+0.9	+1.1	+1.4	+1.6	
G	▼	0	+0.6	+0.8	+1.0	+1.3	+1.6	+1.8	

*NOTE: Initial variation from REF level ± 0.5 dB or less is recorded as "0".

Table 1-3. Example Record of Span Line of ALBO Repeaters with a Faulty Section

Line Filter	Pulse Period Switch Position								Faulty Section
	11	10	9	8	7	6	5	4	
A	REF	0	0	0	0	+0.6	+0.7	+0.8	
B	(0 dB)	0	0	0	0	+0.6	+0.8	+1.0	
C	↓	0	0	0	+0.6	+0.7	+0.9	+1.1	
D		0	0	+0.7	+0.2	+0.2	+0.3	+0.3	◄ - - - - - -
E		0	0	+0.8	+1.0	+1.3	+1.0	+1.1	
F		0	0	+0.9	+1.1	+1.6	+1.5	+1.7	
G	▼	0	+0.8	+1.1	+1.4	+1.6	+1.6	+2.0	

NOTE: Initial variation from REF level ± 0.5 dB or less is recorded as "0".

"A" is closest to the testing office. A slowly rising level occurs as "A" is tested. (Measure 1 pattern at density 4 is particularly difficult for repeaters. A significant change at 4 might be encountered even though the repeater is good.) Because all repeaters are good in Table 1-2, all readings rise smoothly, with no sudden or unusual changes.

1.27 Table 1-3 is an example of readings which might be obtained on the same line as Table 1-2, but with a *faulty repeater* at "D". Notice that "A", "B" and "C" produce gently rising levels. When "D" is tested, a sudden drop in level at Density 7 significantly alters the rising pattern. Repeater trouble is suspected. Erratic readings at "E", "F" and "G" caused by errors at "D", tend to verify the trouble.

1.28 The techniques used for Fault Line trouble testing can be employed for logging an initial performance record. Prior to turning up a new system for service, Fault Line tests should be made and recorded for future reference. If an unusually difficult trouble should occur, a comparison with the original data may help to detect the trouble condition.

NOTE: A sample FAULT LINE TEST RECORD is provided at the end of this manual. It may be duplicated, if desired. We recommend that you set up a form which meets your specific requirements.

SPAN MONITORING

1.29 The 415A-2 can monitor working lines for pulses and errors (bipolar violations). It can also detect an oscillating line when a patch cord is connected from a terminal monitor jack to the PCM SIG IN jack. The PULSES lamp will light if a line signal is present. Bipolar violations will cause the ERRORS lamp to flash. (A "pulse-stretcher" circuit elongates the error pulse to sufficient duration to illuminate the lamp.) The SYSTEM Mb/s control should be switched to the correct bit rate. In the case of 2.37 Mb/s the receiver is conditioned to ignore intentional coded violations built into the T148 "4B3T" (four binary-to-three ternary) signal. At other bit rates *all* bipolar violations will cause the ERRORS lamp to flash.

1.30 If the line should be oscillating due to an unstable condition (particularly lack of a PCM signal), the resultant sine wave-type energy is essentially "bipolar" and might ordinarily be mistaken by a test set for PCM pulses. Since the frequency of an oscillating line is usually much lower than PCM, the 415A-2 recognizes this frequency as an oscillation and lights the OSC LINE lamp.

END-TO-END AND INTERMEDIATE TESTING

1.31 The 415A-2 provides two signals for end-to-end or intermediate point testing: Quasi-Random Word (QRW) and "All Ones" (Fig. 1-8). The Quasi-Random Word is activated by positioning the FUNCTION switch to QRSS (Quasi-Random Signal Source). QRW is a continuously repeated, predetermined pattern totalling 1,048,575 bits. The pattern is arranged to simulate the spectral energy of a normal PCM signal generated by an active terminal. In addition to its apparent "random" character, QRW contains segments of up to 14 "zeros" (no pulses) in sequence, to stress the repeater's resonant clock circuits. QRW is applied to the line at the terminal office. Another 415A-2

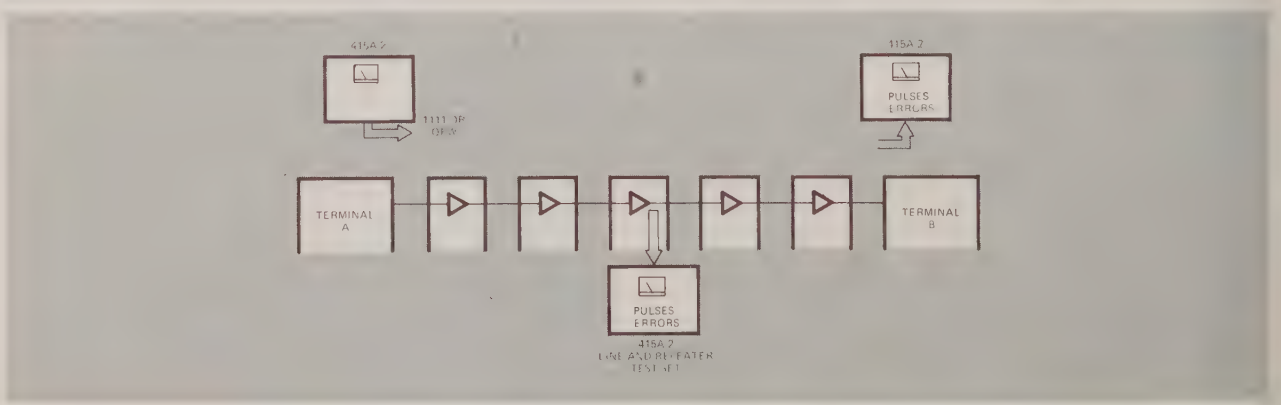

Figure 1-8. End-to-End And Intermediate Testing

at the distant end checks for pulses and errors (bipolar violations). An instrument such as the 418A PCM Error Performance Analyzer can monitor QRW and detect *logic* errors on a bit-by-bit comparison basis.

1.32 Three QRSS functions are provided: In NORM position an error-free QRW pattern is applied to the PCM test signal. In the STOP XMT position the signal generator is turned off. In the XMT ERRORS position a pre-determined number of bipolar violations is introduced into the signal. At 1.544 or 3.152 Mb/s, 8 BPV errors are inserted per each complete quasi-random word. At 2.37 Mb/s rate only 1 error is inserted per word. The error lamp flashing rate or error-count readout registered at the receiving end depends upon the type of test instrument used and its counting limitation.

1.33 The "All Ones" test signal consists of a pulse in *every* time slot. It is selected by turning the FUNCTION switch to 1111. "All Ones" is a simple, easily regenerated pattern because the repeater clock receives a timing pulse in every time slot. Furthermore, spectral energy falls in a relatively narrow range near the center of the system bandwidth (one-half the bit rate). "All Ones" provides a useful test signal which contrasts with the more "difficult" QRW pattern.

SPAN LINE MONITORING

1.34 The 415A-2 can monitor a working PCM system by connecting from the instrument's PCM SIG IN jack to an appropriate send or receive monitor jack. The PULSES lamp lights in the presence of signals. Bipolar violations cause the ERRORS lamp to flash.

PRE-INSTALLATION REPEATER TESTING

1.35 The test set can make extensive pre-installation or troubleshooting tests on individual repeaters brought to the Central Office. It contains a repeater "well" which may be equipped with an optional Insert device to mechanically and electrically interface with the desired repeater. When the repeater (and its Insert) are seated in the repeater well, the 415A-2 provides appropriate power, circuit simulation and test signals.

1.36 Set proper DC power current (Fig. 1-9, A) by turning the FUNCTION switch to CURRENT and adjusting the ADJ control for correct value on the meter. When current is set, move the FUNCTION switch to VOLTAGE (Fig. 1-9, B). The meter should read at or near the manufacturer's specification. (If not, the repeater's power regulation circuit may be defective.) Next, a high DC voltage (200V) is applied between the repeater and its case to check insulation resistance (Fig. 1-9, C). When the HV TEST button is depressed the HV LEAK lamp will light if resistance is too low.

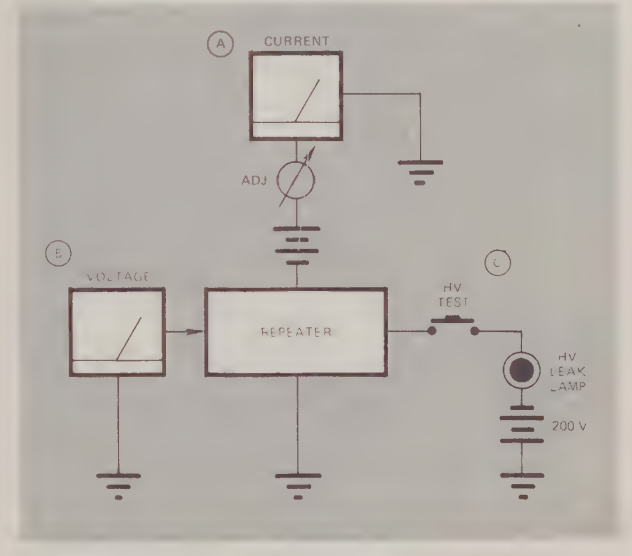

Figure 1-9. Current, Voltage Drop, and Leakage Tests

1.37 Before continuing tests we must set the instrument functions to agree with the type of inserted repeater. There are usually two signal regenerators (Side 1 and Side 2) in each repeater, as shown in Fig. 1-10. A Uni-Directional repeater is wired to handle one direction of transmission for *two* separate systems. (Another Uni-Directional repeater is dedicated to the opposite direction.) A Bi-Directional repeater serves both directions of a single system.

1.38 The 415A-2 is configured to the internal wiring of a repeater under test by the REPEATER TEST switch. Fig. 1-10 shows the setup for Side 1 of a bi-directional repeater. When tests are complete they may be repeated on Side 2 by turning the REPEATER TEST switch to the appropriate setting.

1.39 When GEN XMT and RECEIVE FAULT LINE jacks are unoccupied, the signal

generator, fault line receiver and pulse/error detector are internally connected to the repeater well. An Artificial Line is attached to the generator output to provide simulation of a line section. The ART LINE switch selects ten values of attenuation between 5 dB and 43 dB.

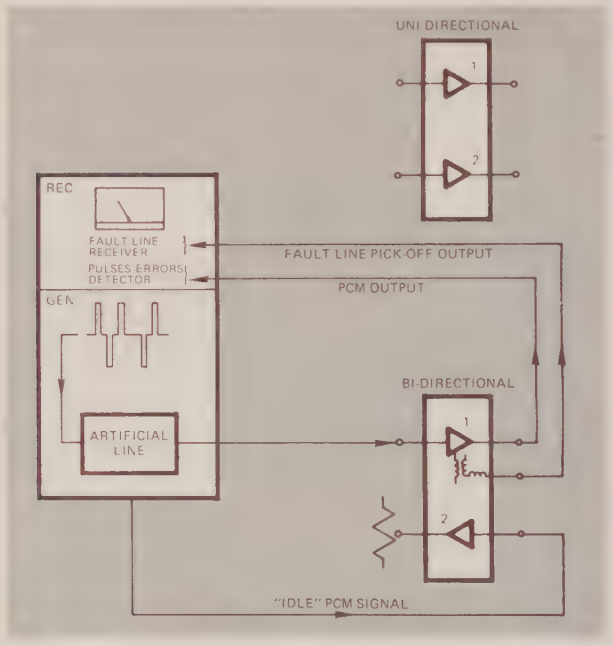

Figure 1-10. Signal Testing of Inserted Repeater

1.40 Because the repeater is locally connected to the test set, QRSS and "All Ones" signal patterns can be sent, and pulses/errors detected. Measure 1, 2 and 3 tests can be made similar to the normal Fault Line function, although in this case a tone-deriving filter is not required. The audio component is detected by *band pass filtering* in the receiver, under control of the LINE FILTER selector.

1.41 Measure 1, 2 and 3 tests are performed as described earlier (for the Fault Line). The LINE FILTER control may be set at any convenient designation (A through M). The RECEIVE FAULT LINE LEVEL control "step" and vernier segments are positioned at the desired "reference point" reading on the meter. It may be noted that the meter reading varies when the LINE FILTER control is advanced from A to M. This is a characteristic of the repeater's transformer winding which picks off the line signal for processing by the Fault Line Filter at a repeater location. If an unusual variation is encountered, trouble may exist in the repeater winding.

1.42 Repeater Side 2, presently idle in Fig. 1-10, is prevented from oscillation by terminating its output and feeding an "idle" PCM signal into the input.

1.43 The "pulse trio" characteristic of Measure 1, 2 and 3 test signals introduces bipolar violations. The ERRORS lamp will normally flash during these tests.

1.44 Quasi-Random word and "All Ones" tests (QRSS or 1111 position of the FUNCTION switch) are made as described earlier. In addition, noise interference may be added to the test signal to simulate crosstalk on the line ("QRSS" or "1111" signals).

NOTE: It is *not* recommended that STOP XMT be used during "QRSS" test of an inserted repeater. Loss of an active signal could cause the repeater to oscillate.

1.45 An Interference signal is available to simulate crosstalk (when testing *inserted* repeaters only). The signal simulates crosstalk on the line (Fig. 1-11). It is a sine wave with frequency close to one half the PCM bit rate:

1.544 Mb/s	770 kHz
2.37 Mb/s	1.182 MHz
3.152 Mb/s	1.570 MHz

(Exact half bit rate is avoided to prevent interference with clock circuits.)

Although the interference generator affects all of the five test signals, it is most meaningful when used with QRSS output. The INTERFERENCE MARGIN dB control is advanced from its OFF position until excessive ERRORS are indicated on the lamp. Setting of the control at this point shows an approximate value of signal-to-noise ratio at which failure occurs. The reading is checked against published S/N ratio of the repeater type under test. (The control should be returned to OFF when not in use.)

1.46 The internal Artificial Line is calibrated (and marked) for 1.544 Mb/s (T1) operation. When inserted repeaters are tested at 2.37 Mb/s (T148) or 3.152 Mb/s (T1C), additional loss will be encountered at a given ART LINE setting. Table 1-4 provides loss values for T148 and T1C for any setting of the ART LINE control (T1). When testing a T148 or T1C repeater, refer to the appropriate column and select a reading nearest the

desired level. Example: 31 dB loss at T1 (the ART LINE setting) provides 38.4 dB loss at T148 and 44.3 dB loss at T1C.

NOTE 1: To test ALBO repeaters over a broad range of input level, it is suggested the ART LINE settings 9 and 24 be used. The values should work well regardless of system bit rate.

NOTE 2: The ART LINE control can be continuously rotated in any direction, for the convenience of those who desire to switch quickly from low values (5 or 9) to high values (40 or 43). There are two "empty" positions between 5 and 43. Disregard any lamp indications which may occur while switching across the empty positions.

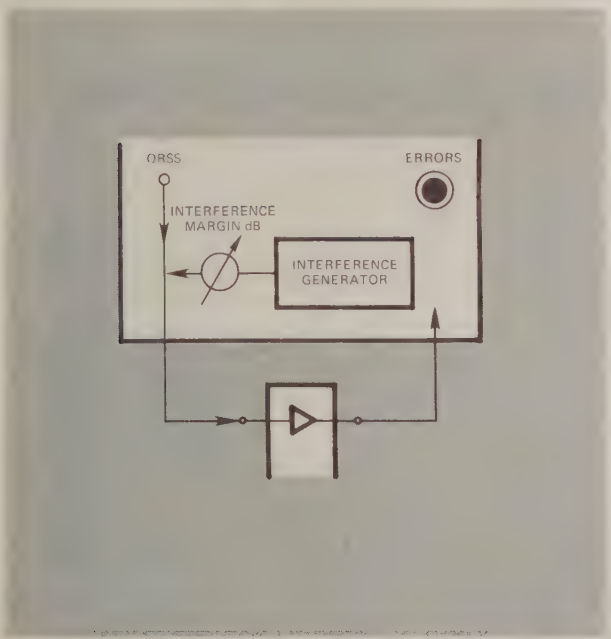

Figure 1-11. Crosstalk Interference Test (Inserted Repeater Only)

OTHER FEATURES

1.47 Inputs and Outputs are available at standard jacks for 310-type plugs. In addition, PCM SIG IN, GEN XMT and FAULT LINE REC include a parallel miniature type jack. FAULT LINE MON jack is provided to monitor the Fault Line. It is useful in locating noise, foreign tone or other troubles which may affect proper operation.

1.48 A GEN MON jack is provided for monitoring output of the pattern generator. A terminating or bridging scope, error counter or other device may be connected. (If a bridging instrument is used we recommend the shortest possible patch cord to reduce effects of capacitance.) The 415A-2 can monitor its own generator output. Connect a patch cord from GEN MON to PCM SIG IN. The monitor permits checking for an error-free signal, or verifying that deliberately inserted errors are actually present in the output.

1.49 The RECORDER OUT connector (BNC-type) produces a TTL- compatible pulse when an ERROR is detected by the 415A-2. Output from the connector drives a scope, event counter or other device.

Table 1-4. T1/T148/T1C ART LINE Loss Comparison

ART LINE (T1 Loss) dB	T148 Loss dB	T1C Loss dB
43	53.3*	61.4*
40	49.6*	57.2*
38	47.1*	54.3*
36	44.6*	51.4*
33	40.9	47.2
31	38.4	44.3
24	29.8	34.3
16	19.9	22.9
9	11.2	12.9
5	6.2	7.1

*Check manufacturer's specifications for information on operation at these maximum values.

2. PHYSICAL DESCRIPTION

INTRODUCTION

2.01 The Sierra 415A-2 is a rugged portable instrument housed in a splashproof metal case with front cover and carrying handle. The cover provides storage space for the attached AC power cord and additional patch cords. Dimensions are 8 inches (20.6 cm) high by 12 inches (31 cm) wide by 8 inches (20.6 cm) deep without cover. Weight, including cover, is about 20 pounds (9 kg). It is designed to operate on 115 V/230 VAC ± 10%, 47.5 to 66 Hz power.

2.02 All operating controls, indicators, and input/output connectors are located on the front panel. The front panel includes a large receptacle into which various optional inserts can be plugged. (An Insert is required to mechanically and electrically interface with the PCM repeater inserted for testing.)

CONTROLS AND INDICATORS

2.03 Operating controls, indicators, and connectors are shown in Fig. 2-1 and described in Table 2-1.

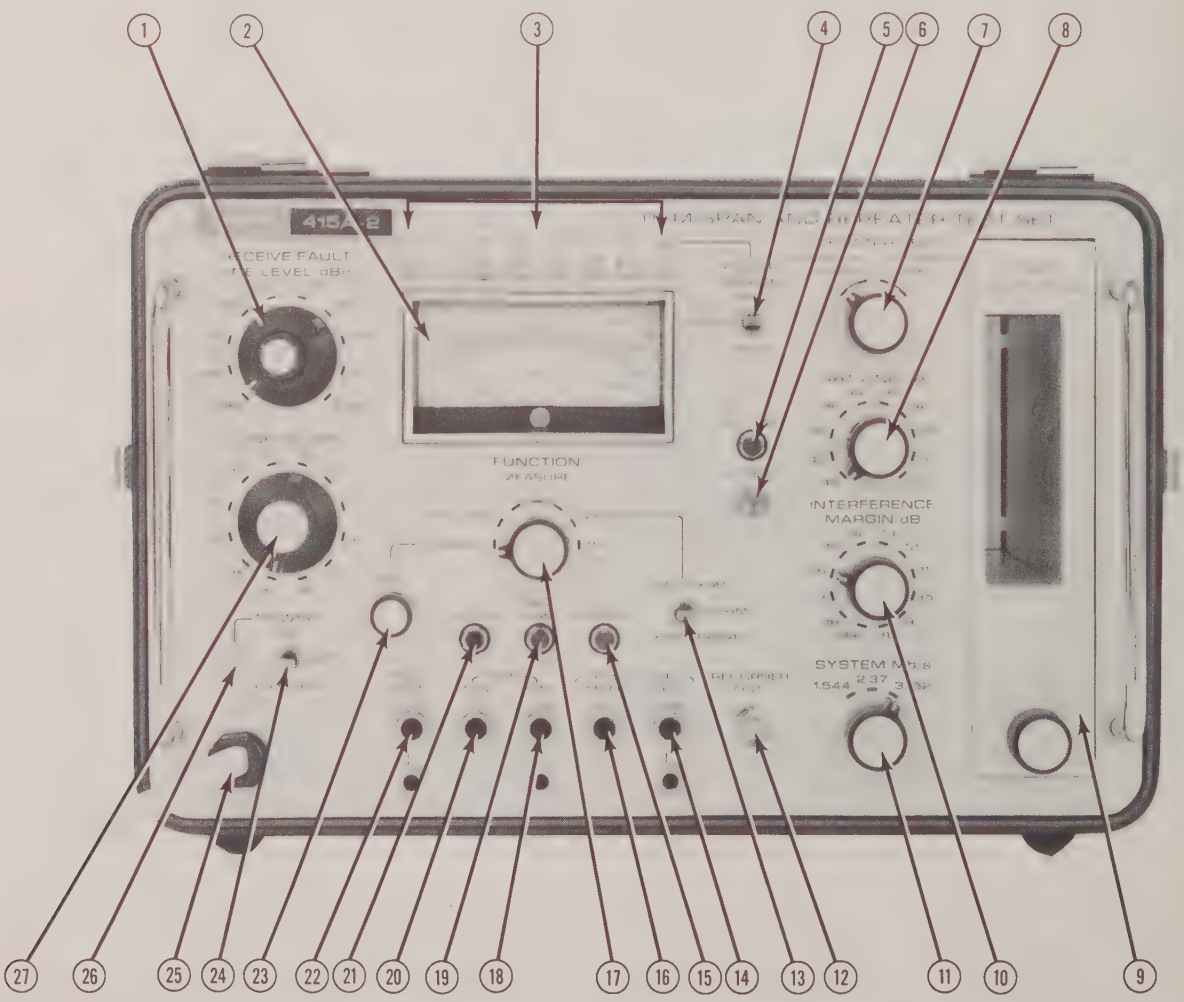

Figure 2-1. Controls and Indicators

Table 2-1. Operating Controls and Indicators

Index No.	Name	Function
1	RECEIVE FAULT LINE LEVEL dBm	Indicates level of tone from Fault Line (in conjunction with meter reading) when *vernier* segment set fully *clockwise*. When otherwise adjusted, vernier permits setting meter to a specific reference point for test purposes.
2	METER	Measures either absolute or "reference" fault line receive tone; measures repeater voltage drop; measures repeater current.
3	PULSE PERIOD Lamps	Indicate pulse density of transmitted Measure 1, 2 or 3 test signal. "11" represents light density (one pulse trio in 11 time slots); "4" is heavy density (one pulse trio in 4 time slots).
4	PULSE PERIOD Switch	Controls density of transmitted Measure 1, 2 or 3 test signal. In REF position causes continuous sending of one pulse trio in 11 time slots (lamp "11" lights). In AUTO position density increases periodically, as shown by advancing illumination of numbered lamps. Stops at "4". In HOLD position stops and holds density at desired point, indicated by lighted number lamp.
5	HV LEAK Lamp	Lights during high voltage test when repeater insulation resistance to ground is less than 1 Megohm ± 50%.
6	HV TEST Pushbutton	When depressed applies 200 VDC to test insulation resistance of repeater inserted into instrument.
7	REPEATER TEST Control	Selects proper *type* (Bi-directional or Uni-directional) and *side* (1 or 2) of repeater inserted in test set.
8	ART LINE dB Control	Selects attentuation value of artificial line in signal path (for local testing of an inserted repeater only). Consists of 10 positions, providing 5 dB to 43 dB loss to simulate cable pair (at 1.544 Mb/s).
9	Repeater Test Receptacle (with Insert)	Provides mechanical and electrical interface for repeater under test. Fig. 2-1 shows a typical optional Insert installed in the receptacle. The insert accepts a specific manufacturer's repeater.
10	INTERFERENCE MARGIN dB Control	Injects an interference signal into the test signal (local test only) to stress repeater inserted in the instrument. Simulates crosstalk effect. Interference increases as control moved toward smaller numbers, which correspond roughly to signal-to-noise ratio.
11	SYSTEM Mb/s Control (1.544, 2.37, 3.152 Mb/s)	Selects proper bit rate for PCM line or repeater under test.
12	RECORDER OUT Connector	Provides pulse output corresponding to each bipolar violation detected. For event counter, strip recorder or other device.
13	STOP XMT/NORM/XMT ERRORS switch	Conditions Quasi-Random Signal Source (if selected by FUNCTION switch). STOP XMT stops the signal; NORM causes continuous transmission of error-free

Table 2-1. Operating Controls and Indicators (continued)

Index No.	Name	Function
		QRSS signal; XMT ERRORS causes predetermined errors (bipolar violations) to be introduced into the QRSS signal.
14	FAULT LINE REC Jack	Accepts patch cord from the Fault Line. Consists of parallel arrangement of 310-type jack and an alternate miniature type jack.
15	ERRORS Lamp	Lights when bipolar violations are detected in the received signal (at PCM SIG IN jack or from inserted repeater under test).
16	FAULT LINE MON Jack	Provides for monitoring audio tones from the Fault Line.
17	FUNCTION Control	Selects certain major functions of the test set. CURRENT position permits adjustment of current supplied to inserted repeater under test. VOLTAGE position measures inserted repeater voltage drop. MEASURE 1, 2, and 3 positions provide special signal patterns for Fault Line and inserted repeater testing. QRSS (Quasi-Random Signal Source) position generates standard quasi-random word. "1111" position generates all binary "ones", causing each PCM time slot to contain a pulse.
18	GEN XMT Jack	Generator output jack. Provides signals to the PCM line for testing. 310-type jack is paralleled by an alternate miniature type jack.
19	OSC LINE Lamp	Lamp lights if test set detects a low frequency oscillating line condition. Circuit operative when PCM SIG IN jack used to monitor a PCM system line.
20	GEN MON Jack	Provides for monitoring test signal output of test set, with oscilloscope, error counter or other device.
21	PULSES Lamp	Lights to indicate presence of pulses (at PCM SIG IN jack or at output of inserted repeater under test).
22	PCM SIG IN Jack	Provides for error monitoring of PCM line. Connects to a suitable system line monitoring jack.
23	CURRENT ADJ Control	Adjusts proper current to an inserted repeater under test, as indicated by meter current reading.
24	POWER Switch	Turns on AC power to test set. Includes spring return position (LAMP TEST) to check condition of all front panel lamps.
25	Power Cord	Permanently connected AC power cord.
26	POWER ON Lamp	Lights when POWER switch turned on.
27	LINE FILTER Control	Selects correct pulse configuration to generate desired audio component in Measure 1, 2 or 3 test signal. Also selects correct receive filter for incoming Fault Line tone.

3. FUNCTION DESCRIPTION

3.01 The 415A-2 consists of a pattern generator, counter logic control, receiver, error detector, repeater tester, and power supply.

PATTERN GENERATOR

3.02 The pattern generator provides MEAS 1, MEAS 2 and MEAS 3, Quasi-Random Word, and "All Ones" signals. It includes various clock oscillators, pulse power output stage, and certain logic controls.

3.03 Crystal-controlled Clock Oscillators set the basic transmission speed of all generated test patterns. They are controlled by the SYSTEM Mb/s switch. Three line bit rates may be selected by the control: 1.544 Mb/s, 2.37 Mb/s and 3.152 Mb/s. The clock circuit generates a succession of precisely divided "time slots" into the Pattern Generator and its associated format-determining input circuits.

3.04 The standard Quasi-Random Word (QRW) is connected to the Pattern Generator when the FUNCTION switch is positioned to QRSS ("Quasi-Random Signal Source"). It is a repetitive sequence of 1,048,575 bits. QRW simulates an active PCM terminal by generating a similar spectrum of energy. The signal is limited to a maximum of 14 digital zeros in sequence to correspond with current system design practice. (Good repeaters can generally tolerate 14 zeros in sequence, i.e., no pulses during 14 time slots, while marginal repeaters may fail because their resonant input circuits tend to fall out of step during lengthy absence of pulses.)

3.05 At 1.544 and 3.152 Mb/s rates QRW is produced by a 20-bit shift register and associated gate circuits ("$2^{20} - 1$" bit count). At 2.37 Mb/s rate the clock drives a special "4B3T" (Four Binary to Three Ternary) encoder to accommodate specific line coding of the T148-type PCM system.

NOTE: Bipolar line signals found in T1, T1C, etc. systems are referred to as AMI (Alternate Mark Inversion). Each pulse is followed by a pulse of the *opposite* polarity. By contrast, 4B3T is a special coding technique which causes frequent violations of the AMI principle.

3.06 When the FUNCTION switch is positioned to MEASURE 1, 2, or 3 the pattern generator is conditioned to produce special groups of bipolar pulses which vary at an audio rate selected by the LINE FILTER switch. When the FUNCTION switch is positioned to "1111" the pattern generator produces all "ones", that is, every time slot will be occupied by a pulse.

3.07 Output of the Pattern Generator drives the Output Amplifier, which produces a line signal of 6V peak-to-peak (3V base-to-peak). This pulse amplifier generates a pulse only when commanded by the Pattern Generator. Polarity of the pulse is also determined by the Pattern Generator.

3.08 A switch associated with the QRSS function can initiate pre-determined bipolar violations (T1, T1C only) into the Pattern Generator (XMT ERRORS) or turn off the output amplifier to momentarily stop transmission of signals (STOP XMT).

3.09 In the MEASURE 1, 2 and 3 positions the Pattern Generator can be controlled by the Counter/Logic circuit, which determines the density of pulses in the test signals. The PULSE PERIOD switch determines whether density will be lightest (REF position); or allowed to progress periodically toward greater density (AUTO), or to hold at a specific density (HOLD).

RECEIVER

3.10 The Receiver circuit includes input amplifiers and bandpass filters to process the incoming tone signal from the Fault Locating Pair. The RECEIVE FAULT LINE LEVEL control adjusts the gain of the receiver. A section of the LINE FILTER switch selects correct high and low pass filter components to provide a narrow audio bandpass at the desired frequency.

3.11 The received tone is fed into a Correlator which is conditioned to recognize the desired audio tone established by the LINE FILTER control. Output of this synchronous detector is a DC potential which varies according to the level of

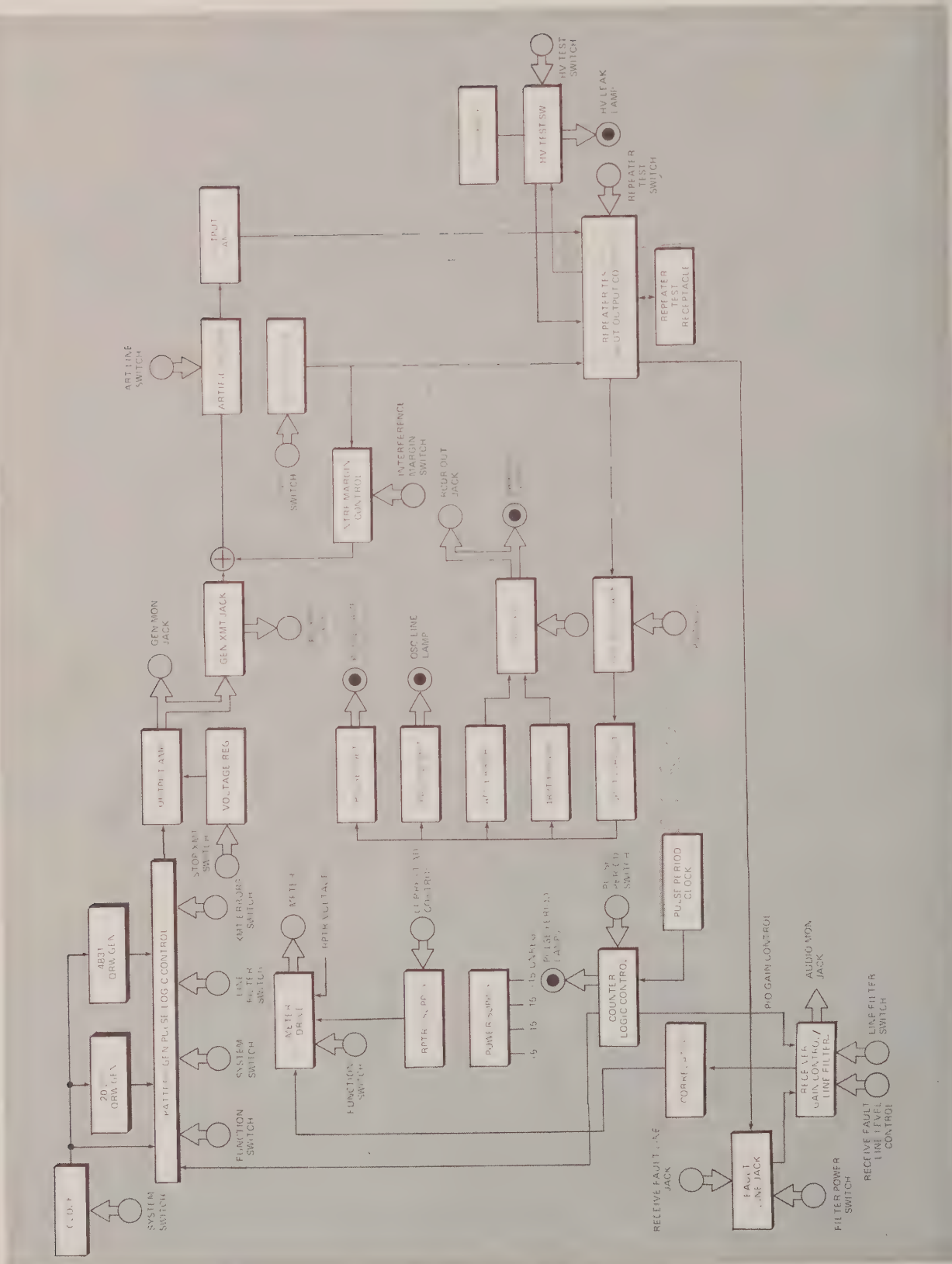

Figure 3-1. Block Diagram

the received tone. Output of the Correlator drives the Meter. The correlator is essentially a finely tuned tracking bandpass filter (band-width about 20 Hz). It is capable of maintaining the narrow pass band without need for manual tuning circuits.

ERROR DETECTOR

3.12 The error detector includes all error, pulse and oscillating line detecting circuitry. The *Pulses* detector recognizes line signals and lights the PULSES lamp.

3.13 When the SYSTEM Mb/s switch is positioned in either 1.544 or 3.152 Mb/s, the *"AMI Errors"* Detector is operative. Any violation of the alternate mark inversion rule will activate the detector and light the ERRORS lamp.

3.14 When the SYSTEM Mb/s switch is positioned to 2.37 Mb/s, the *4B3T Errors Detector* is now operative. It is designed to ignore the coded bipolar violations and light the ERRORS lamp only when violations are received out of the expected pattern.

3.15 The *Oscillating Line* Detector lights the OSC LINE lamp when it detects frequencies less than 100 kHz at the PCM SIG IN jack.

REPEATER TESTER

3.16 The Repeater Tester includes circuits for input/output interface with an inserted repeater. Components of the tester include a signal generator, an interference generator, an artificial line, and repeater voltage, current and insulation resistance test circuits.

3.17 The *Artificial Line* provides simulated characteristics of a line for testing an inserted repeater. Attenuation is varied by the ART LINE dB switch, from 5 to 43 dB loss (at 772 kHz). When the GEN XMT and PCM SIG IN jacks are unoccupied the Generator signal is fed into the artificial line, and the Error Detector circuits monitor the repeater output.

3.18 *Interference* is simulated by a sine wave signal at a frequency close to one-half the bit rate selected by the SYSTEM Mb/s switch. When interference is increased (clockwise direction of the INTERFERENCE MARGIN switch) the simulated crosstalk energy should eventually cause errors at the repeater output, as indicated by a flashing ERRORS lamp. Designations on the INTERFERENCE MARGIN switch (18 through 8) are generally related to signal-to-noise ratio readings. Switch readings were calibrated on the basis of an "all ones" signal (FUNCTION switch to 1111) and 31 dB attenuation (ART LINE to 31).

3.19 To test *Insulation Resistance* the HV TEST pushbutton is depressed to apply 200 VDC between the repeater circuitry and its chassis. If resistance less than 1 Megohm ± 50% is encountered the HV LEAK lamp will light.

POWER SUPPLY

3.20 The power supply includes regulated +5V for logic circuits, +15V and −15V for other circuits, and −200V for repeater insulation resistance testing.

4. SPECIFICATIONS

4.01 Specifications for the 415A-2 Span and Repeater Test Set are shown in Table 4-1.

Table 4-1. Test Set Specifications

PULSE TRANSMITTER

Bit Rate:	1.544, 2.37 or 3.152 Mb/s (switchable)
Time Slots:	1.544: 648 ns 2.37: 422 ns 3.152: 317 ns
Pulse Width, Nominal:	1.544: 320 ns 2.37: 211 ns 3.152: 160 ns
Pulse Rise or Fall Time:	1.544: 80 ns 2.37: 50 ns 3.152: 30 ns
Pulse Overshoot:	10 to 30% of pulse amplitude
Pulse Amplitude:	± 3V ± 10% base-to-peak (6V ± 10% peak-to-peak)
Audio Component Frequencies (Hz):	A 832, B 928, C 1048, D 1206, E 1340, F 1508, G 1722, H 2008, J 2193, K 2413, L 2680, M 3017
Audio Component Accuracy:	± 2%
Interference Margin Signal:	Sine wave, level adjustable from 8 to 18 dB below level of all 1's signal at repeater input. 3.152: 770 kHz 2.37: 1.182 MHz 3.152: 1.570 MHz

FAULT LINE RECEIVER

Filter Frequencies:	Same as transmitter audio component frequencies
Input Range:	–90 dBm to 0 dBm
Input S/N Requirement:	15 dB S/N minimum in a ± 10 Hz bandwidth centered on desired fault locating frequency.
Input Impedance:	900 ohms ± 10%
Level Reading Accuracy:	± 1.0 dB at 0 dBm on meter; ± 2.0 dB at –10 dBm on meter
Meter Accuracy:	± 3% of full scale
Common Mode Rejection:	60 dB minimum at 4 kHz
PCM Signal Input:	±1.0 to ± 4.0 V, base-to-peak (2.0 to 8.0 V peak-to-peak)
High Voltage:	200 ± 10% VDC. Lamp ON indicates less than 1 Megohm insulation resistance ± 50%.

Table 4-1. Test Set Specifications (continued)

Temperature Range:	Operating: 0 to +50°C Storage: –40 to +65°C Maximum Humidity: 95%
Power:	115/230 VAC ± 10%, 47.5 to 66 Hz
Dimensions, Nominal:	Approx. 8 in. H x 12 in. W x 8 in D
Weight:	Approx. 20 lbs.

5. OPERATION

RECEIVING INFORMATION

5.01 When the test set is received, unpack and inspect it for signs of physical damage. Check the equipment received against the order. Retain the shipping carton.

CAUTION: The chrome-plated handles on the front panel are designed primarily to protect the front panel controls. They are not to be used for transporting the set for any appreciable distance or for any rough handling. Use the carrying handle on the case cover.

5.02 A special Repeater Test Set Receptacle is required for the repeater slot to interface with a specific type of repeater when local tests are desired. It is not included with the 415A-2, and must be ordered separately.

5.03 Patch cords are required for the span line fault locating and performance tests. They must have a 310-type (tip-ring-sleeve) plug on the instrument end. Certain jacks will accept a cord with a miniature plug on the instrument end. Patch cords are generally available from various manufacturers. A 310 plug-to-310 plug cord is available from Sierra (Part No. 916400037).

5.04 If the test set is damaged or does not operate properly, contact the Sierra Customer Service Department for instructions.

Address:
Customer Service Department
Lear Siegler, Inc.
Sierra Electronic Division
3885 Bohannon Drive
Menlo Park, California 94025

Telephone:
(415) 321–5374

TWX:
910–373–1282

NOTE: If defective equipment is to be returned to the factory or other authorized Sierra repair facility, we recommend that you first contact the Sierra Customer Service Department for specific instructions prior to packing and shipping the test set.

POWER REQUIREMENTS

5.05 The 415A-2 operates from a 115/230 V, 47 to 63 Hz power source. Check the AC power selector switch to insure that it is set for the correct line voltage. The selector switch is located on the rear panel of the chassis (Fig. 5-1). The switch can be actuated by a small screwdriver blade. (The AC fuse is also located on the rear panel.)

WARNING: Turn the power switch off and disconnect the AC cord before removing the instrument from its case.

5.06 The case may be removed by placing the test set on the front panel handles, loosening the four screws at the rear, and lifting the case clear.

5.07 Replace the case, tighten the screws and place the test set in its normal position. Reconnect the power cord, and set the POWER switch to ON. The POWER lamp should light to confirm that power is on.

5.08 Set the POWER switch momentarily to the LAMP TEST position. The following lamps should light:

ERRORS; OSC LINE; HV LEAK (Red)
POWER; PULSE PERIOD lamps 4 thru 11 (White)
PULSES (Green)

Figure 5-1. AC Selector Switch and Fuse

OPERATIONAL TEST

5.09 To insure that the test set is working correctly, you may wish to perform this optional operational test. Signals are patched from the pulse generator output (GEN MON) to the receiver input (PCM SIG IN). It is suggested that this test be performed periodically. If results deviate significantly from anticipated results, servicing may be necessary.

Operational Test		
Initial Set-Up		
Step	**Procedure**	**Result**
1	Connect Power cord.	
2	Momentarily depress POWER switch to LAMP TEST position.	All front panel lamps light.
3	Set POWER switch to ON.	POWER lamp lights.
4	Set SYSTEM Mb/s to 1.544. (T1)	
5	Set LINE FILTER switch to A.	
Fault Line Input Check		
Step	**Procedure**	**Result**
6	Patch the GEN MON jack to the FAULT LINE REC jack.	
7	Set the PULSE PERIOD switch to REF.	Lamp 11 lights.
8	Set the FUNCTION switch to MEASURE 1.	
9	Adjust the RECEIVE FAULT LINE LEVEL control to –60, then adjust vernier control for a meter reading of 0 dB.	
10	Set the FUNCTION switch to MEASURE 2 position.	Meter should read between –5 and –7 dB.

Operational Test (continued)		
Fault Line Input Check (continued)		
Step	**Procedure**	**Result**
11	Set the FUNCTION switch to the MEASURE 3 position.	Meter should read within 1 dB of Step 10.
12	Reset the FUNCTION switch to the MEASURE 1 position.	
13	Switch PULSE PERIOD switch to AUTO.	PULSE PERIOD lamps light in sequence 11 through 4. Meter reading may rise up to 2 dB through the range.
13A	Reset PULSE PERIOD switch to REF.	
PCM Signal Input Check		
Step	**Procedure**	**Result**
14	Transfer the patch cord from FAULT LINE REC to PCM SIG IN jack. .	
15	Rotate the FUNCTION switch through MEASURE 1, 2, and 3 positions.	PULSES and ERRORS lamps light.
16	Set FUNCTION switch to QRSS and toggle switch to NORM.	PULSES lamp ON; ERRORS lamp off.
17	Set toggle switch to XMT ERRORS.	ERRORS lamp flashes.
18	Set toggle switch to STOP XMT.	PULSES and ERRORS lamps go out.
19	Reset toggle switch to NORM.	
Line Filter Transmission Check		
Step	**Procedure**	**Result**
20	Transfer patch cord from PCM SIG IN to FAULT LINE REC jack.	
21	Set FUNCTION SWITCH to measure 1.	
22	Rotate the LINE FILTER switch through all the settings, then return to A.	Meter reading should increase approximately 1.3 dB per step.
System Mb/s Check		
Step	**Procedure**	**Result**
23	Rotate the SYSTEM Mb/s switch through the 2.37 and 3.152 settings; each time perform steps 6 through 19. NOTE: It is not possible to verify the operation of the REPEATER TEST, ART LINE, and INTERFERENCE MARGIN functions with these initial tests.	

SPAN LINE FAULT LOCATING

5.10 This test is performed on a PCM line that is removed from service. The 415A-2 sends out an "interrogating" signal on the Send side of the line, comprising a special PCM-type test signal with an "audio" pulse pattern determined LINE FILTER control. A filter at the desired repeater location derives an audio tone from the pulse pattern and sends it over the Fault Line back to the 415A-2 to be displayed on the meter. Any deviation from the anticipated level or the absence of a signal indicates a fault and its possible location. Refer to paragraphs 1.07 through 1.28 for more information.

Span Line Fault Locating		
Pre-Test Set-Up		
Step	**Procedure**	**Result**
1	Turn POWER switch ON.	POWER lamp lights.
2	Patch GEN XMT jack to input of span line under test.	
3	Patch fault locating pair of the system under test to the FAULT LINE REC jack.	
4	Set SYSTEM Mb/s switch to data rate of span line.	
Testing the Nearest Repeater		
Step	**Procedure**	**Result**
5	Turn LINE FILTER switch to the frequency code letter of the nearest repeater's Fault Line filter.	
6	Set FUNCTION switch to MEASURE 1.	
7	Set PULSE PERIOD switch to REF.	Lamp 11 lights.
8	Set RECEIVE FAULT LINE LEVEL vernier (center knob) fully clockwise.	
9	Adjust RECEIVE FAULT LINE LEVEL for a meter reading of 0 dB. Use the vernier for fine adjustment.	
10	Set FUNCTION SWITCH to MEASURE 2.	Meter should read between –5 and –7 dB.
11	Set FUNCTION switch to MEASURE 3.	Meter should read within 1 dB of Step 11.
12	Set FUNCTION switch back to MEASURE 1.	
13	Set PULSE PERIOD switch to AUTO.	Lamps above the meter (11 through 4) light in sequence from left to right as the pulse density increases. The level of the return signal can be read on the meter, and a record of these readings should be kept in a form similar to that illustrated in Tables 1-2 and 1-3. See paragraphs 1.25 through 1.27 for more information.

Span Line Fault Locating (continued)		
Testing Other Repeaters		
Step	**Procedure**	**Results**
14	Repeat steps 6 through 14 for each succeeding repeater associated with the fault locating pair.	
15	If a long span line (with more than 12 repeater locations) is monitored by two fault locating pairs at one terminal office, patch to the second fault line and repeat steps 6 through 14 to obtain readings from the other group of repeater locations.	

SPAN LINE PERFORMANCE TESTS

5.11 This test is performed on an out-of-service line. It uses the 415A-2 to transmit a Quasi-Random Word and an "All Ones" signal. The test signals can be received at the far end terminal using another 415A-2. Refer to paragraphs 1.32 through 1.34 for detailed information.

5.12 The QRW may also be monitored at an intermediate repeater site using a Sierra 417A PCM Line and Repeater Test Set; Sierra 414A PCM Error Counter; or equivalent.

Span Line Performance Tests		
A. At the Transmitting Terminal		
Step	**Procedure**	**Result**
1	Turn POWER switch ON.	POWER lamp lights.
2	Connect GEN XMT jack to transmit input of span line under test.	
3	Set SYSTEM Mb/s switch to system data rate.	
4	Set the INTERFERENCE MARGIN control OFF.	
5	Set FUNCTION switch to QRSS.	
6	Set QRSS switch to NORM. NOTE: This switch can be operated to the XMT ERRORS or STOP XMT positions by arrangement with the technician at the receiving terminal (to light the ERRORS lamp or identify the line under test by interrupting the transmitted signal).	Test set transmits QRW over PCM line to distant end.
7	Set the FUNCTION switch to 1111.	Test set transmits "1111" signal over PCM line to distant end.

Span Line Performance Tests (continued)		
B. At the Receiving Terminal		
Step	**Procedure**	**Result**
8	Turn POWER switch ON.	POWER lamp lights.
9	Set SYSTEM Mb/s switch to system data rate.	
10	Patch PCM line under test to PCM SIG IN jack of 415A-2.	1. When Send End transmits QRW (NORM), observe PULSES lamp lighted. Observe ERRORS lamp for flashing. NOTE: Occasional errors may or may not be acceptable, depending on frequency of flashing and the customer's performance specifications. More than 30 errors per second will cause the lamp to be lighted more or less continuously. 2. When Send End transmits 1111, observe as in (1), above. NOTE: The "All Ones" signal consists of a pulse in every time slot. It places less stress on the line than QRW or a normal PCM bit stream. If QRW (1, above) causes excessive errors, it might be valuable to check a "1111" signal to see if errors continue. This may provide a clue to the nature of the trouble.
11	When the span line has been tested satisfactorily, the return path can be tested by reversing roles of the two 415A-2's and repeating the Span Line Performance Tests.	

ATTACHED REPEATER TESTS

5.13 In this test a repeater is plugged into the test set and checked for leakage resistance, DC voltage drop, pulses, errors, balance and signal-to-noise performance. A final Merit test determines the maximum pulse density at which the repeater can accurately regenerate the applied input signals. During the Merit test the repeater is heavily stressed by unbalanced signals with pulse densities higher than those encountered by a repeater in normal use. An absolute value cannot be given for these merit tests but a comparison of results can be made.

NOTE: The merit test may be useful in evaluating line and repeater problems, however, repeaters should not be rejected on the basis of this test unless the manufacturer provides specific performance requirements for a merit test.

5.14 Additional instructions on testing of office repeaters are contained on the front panel of Sierra office repeater inserts. Two general cautions should be considered when testing office repeaters:

1. Repeater powering options must be conditioned for correct operation.

2. Office repeater regenerators are designed to operate on shorter cable sections than line repeaters.

Attached Repeater Tests		
A. Pre-Test Set-Up		
Step	**Procedure**	**Result**
1	Plug the desired Insert into the repeater test receptacle, to interface with a given repeater.	
2	Turn POWER switch ON.	POWER lamp lights.
3	Set REPEATER TEST switch to position required for the repeater under test (BI-DIR or UNI-DIR) and the side to be tested (SIDE 1 or SIDE 2).	
4	Set the CURRENT ADJ knob fully *counter-clockwise*.	
5	Set the FUNCTION switch to CURRENT.	
6	Plug the repeater into the test slot. NOTE: ALBO: This repeater can be plugged directly into the test slot. LBO: Install an 'A' type LBO module on the repeater before plugging into the test slot.	
7	Determine from manufacturer's specification the current required for the repeater. Turn ADJ knob until this value is indicated on meter.	
8	Set LINE FILTER switch to Position A.	
9	Set the INTERFERENCE MARGIN switch OFF.	
10	Set the PULSE PERIOD switch to REF.	Lamp 11 lights.
11	Set the FUNCTION switch to QRSS and the toggle switch to NORM.	Observe PULSES lamp lighted.
12	Set the ART LINE switch to 31 dB. NOTE: The ART LINE dB switch is continuous, and may be switched directly from –5 to –43. There are two idle positions between these two points. Ignore any lamp indications while switching through these positions.	

Attached Repeater Tests (continued)		
B. Voltage Test		
Step	**Procedure**	**Result**
13	Push the HV TEST button (Not applicable to office repeaters)	HV LEAK lamp should *not* light. If the lamp lights the insulation is defective.
14	Set FUNCTION switch to VOLTAGE position.	Volt drop indicated on the meter should be as specified by the manufacturer.
C. Pulses and Errors Test		
Step	**Procedure**	**Result**
15	Verify FUNCTION switch set to QRSS and toggle switch to NORM. NOTE: Some repeaters may not be specified at all cable lengths. Consult repeater manufacturer's specifications to determine operating range of repeaters. (Office repeaters are typically designed for short cable sections.)	PULSES lamp should light, indicating that the repeater is regenerating the QRW signal. ERRORS lamp should *not* light. If occasional errors occur, the lamp will flash each time. If lamp remains on (with a possible slight flicker) the error rate is greater than 30 per second.
16	Step the ART LINE switch through the following settings: 9; 16; 31. (Optional step) NOTE: Some repeaters may not be specified for operating at all cable lengths.	ERRORS lamp should *not* light.
17	Depress the QRSS toggle switch to the XMT ERRORS position. NOTE: The "XMT ERRORS" error rate is eight errors per word for 1.544 and 3.152 Mb/s position of the SYSTEM Mb/s switch. The error groupings are such that the pulse stretching circuitry associated with the ERRORS lamp causes the lamp to flash three times per word. The visual effect is three flashes in quick succession followed by a slight pause, all in less than one second. In the 2.37 Mb/s position, 1 error is inserted per word.	PULSES lamp should remain on and the ERRORS lamp should flash as the repeater regenerates the errors transmitted.
18	Return QRSS toggle switch to NORM.	
D. Balance Test		
Step	**Procedure**	**Result**
19	Set FUNCTION switch to MEASURE 1. (Verify ART LINE set to 31.)	

Attached Repeater Tests (continued)		
D. Balance Test (continued)		
Step	**Procedure**	**Result**
20	Adjust RECEIVE FAULT LINE LEVEL control for meter reading of 0 dB.	
21	Set FUNCTION switch to MEASURE 2 position.	Meter should read between –5 and –7 dB.
22	Set FUNCTION switch to MEASURE 3 position.	Meter should read within 1 dB of step 22.
23	ALBO Repeater Only: Also perform steps 20 through 24 with the following ART LINE settings: 9; 16. Set to 24.	Meter readings should be similar to the previous test.
E. Signal-to-Noise Test		
Step	**Procedure**	**Result**
24	Set FUNCTION switch to QRSS (NORM). (Verify ART LINE set to 24.)	
25	Rotate INTERFERENCE MARGIN control clockwise.	At a specific setting the ERRORS lamp should flash. The value indicated on the control knob scale should correspond with the manufacturer's wide-band signal-to-noise specification.
26	Reset INTERFERENCE MARGIN control to OFF.	
F. Optional Merit Test (Refer to paragraph 5.13, p. 24)		
Step	**Procedure**	**Result**
27	Set FUNCTION switch to MEASURE 1.	
28	Set PULSE PERIOD switch to AUTO.	Lamps above the meter (11 through 4) light in sequence from left to right as the pulse density increases. The level of the output can be read on the meter.
29	Observe the meter for variation. (Refer to para. 5.13)	
G. Testing Other Side of the Repeater		
Step	**Procedure**	**Result**
30	Return to step 3 (PRE-TEST SET-UP) and repeat tests.	

Attached Repeater Tests (continued)		
H. Testing Additional Repeaters		
Step	Procedure	Result
31	Return to step 3 (PRE-TEST SET-UP) and repeat tests.	

6. FIELD MAINTENANCE

GENERAL

6.01 Operator maintenance procedures given in this manual are limited to fuse and lamp replacement.

6.02 If trouble conditions occur which cannot be readily identified or corrected in the field, contact the Sierra Customer Service Department for information and instructions (see para. 5.04 for address and telephone number).

NOTE: If defective equipment is to be returned to the factory or other authorized Sierra repair facility, first contact the Customer Service Department for specific instructions regarding packing and shipping.

FUSE REPLACEMENT

6.03 The 415A-2 has an AC fuse located on the rear panel of the chassis. If AC power appears to be lost, disconnect the power cord, turn the test set onto the handles on the front panel, and loosen the four screws on the back panel. Lift the case clear of the chassis and check the fuse on the rear panel.

LAMP REPLACEMENT

6.04 The indicator lamps on the front panel are identical. To replace a lamp, unscrew the lens cover and pull the lamp out. Insert a new lamp and screw down lens cap. The lamp is lightly spring-loaded.

CAUTION: Use only lamps specified at 20 ma. Lamps requiring more power may damage the test set.

Table 6-1. Replaceable Fuse

Voltage	Sierra Part No.	Description	Manufacturer	Mfr Part No.
115	913200033	1/4 A slow-blow 250 V	Littelfuse Bussman	323.250 MDL-1/4
230	913200050	1/8 A slow-blow 250 V	Littelfuse Bussman	323.125 MDL-1/8

Location	Line Filter	Density								Faulty Section
		11	10	9	8	7	6	5	4	

Fault Line Test Record (Sample Format)

NOTES

WARRANTY

SIERRA ELECTRONIC DIVISION, LEAR SIEGLER, INC. warrants products manufactured by it to be free from defects in material and workmanship and to meet the applicable specifications under normal use and service for a period of 12 months from the date of original shipment by us. Our obligation under this warranty is limited to the repair or replacement of such products which, after having been returned to the factory or a point designated by us, shall be examined and in our sole opinion, found defective and that such defect was not induced by causes external to the product. Alternately, SIERRA may elect to issue credit for any such defective product. All products to be repaired or replaced shall be returned prepaid to the designated place of repair in accordance with authorization and packing and shipping instructions issued by SIERRA. Return shall not be made until such authorization and instructions are issued. Each returned product shall be accompanied by a statement or report fully stating the claimed defects and any other pertinent information concerning the failure.

SIERRA's responsibility under this warranty does not apply to any products which have been repaired, worked upon or altered by persons not authorized by us so as to in our sole judgement, injure the stability or reliability of such product, or which have been subject to misuse, negligence or accident, or where applicable, the serial number has been altered, effaced or removed. SIERRA shall not be liable for damages resulting from the use of the purchased product, nor shall SIERRA be responsible for any failure in the performance of other items to which the purchased product is connected or the functioning of an entire system or parts of any system of which the purchased product may be a part.

SIERRA reserves the right to make changes in the design or construction of any of its products at any time without incurring any obligation to make changes whatever on units previously purchased. Accessories, including but not limited to all vacuum tubes, fuses, pilot lamps and batteries used with our products are not covered by this warranty. A test setup charge of $25.00 will apply to any returned instrument or microwave component which, after test, is found to meet the applicable specifications.

This warranty is in lieu of all other warranties, expressed, implied or statutory. No representative or person is authorized to represent nor assume for SIERRA any liability in connection with the sale of products other than set forth herein. IN NO EVENT SHALL SIERRA BE LIABLE FOR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES.

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LEAR SIEGLER, INC.
SIERRA ELECTRONIC DIVISION
3885 Bohannon Drive Menlo Park, CA 94025
Tel. (415) 321-5374 TWX 910-373-1282